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RTCA Special Committee 186, Working Group 3

ADS-B 1090 MOPS, Revision A

Meeting #9

Action Items 8-6 and 8-7
Proposed Change to Appendix I to Include Additional Multiple Sample Enhanced Decoding Technique

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SUMMARY
This working paper contains proposed changes to Appendix I of the ADS-B 1090 MOPS to include an additional enhanced bit and confidence declaration technique. This is in response to Action Item 8-6. The description is not specific to any one sampling rate in order to address Action Item 8-7.

This working paper contains proposed changes to Appendix I of the ADS-B 1090 MOPS to include an additional enhanced bit and confidence declaration technique. This is in response to action item 8-6. The following text contains the proposed changes:

Editorial changes to I.4.2.1:

I.4.2.1 Overview

The current technique of declaring a bit based upon the higher of the two chips will generate errors in cases of higher level overlapping Mode A/C fruit (Figure I-2, part c). The use of amplitude to correlate the received pulse with the preamble pulse level will improve bit declaration accuracy. ~~Three~~ Four techniques have been investigated. One is a very simple approach that uses only the amplitude measured at the center of each chip. The ~~second and third~~ remaining three follow a somewhat more complex approach that takes advantage of the four samples per chip that are taken in the current technique to establish bit confidence. Each of these techniques is described in the following paragraphs.

Add the following section:

I.4.2.5 Multiple Amplitude Approach Without using Lookup Tables
(*or should we name it?)*

The fourth enhanced bit and confidence declaration technique makes use of all samples taken for each Mode S bit position and determines the bit and confidence value. But instead of using the sample amplitude pattern to do a table lookup, calculations are performed that result in two numerical scores that quantify how well the sample pattern matches a transmitted '1' and how well the pattern matches a transmitted '0'. Whichever score is higher determines the bit value and the amount of the difference determines if confidence is high or low.

To begin, all samples in each Mode S bit are compared to the preamble reference level. Samples that fall within two categories are of interest, those that match the preamble in amplitude and those that indicate a lack of transmitted energy. To that end, the technique utilizes two of the previous four quantized levels:

0: below threshold (-6 dB relative to the preamble)

2: within the +/- 3 dB preamble window

Four counts are produced that contain the number of samples in each chip that are of the above two categories.

1ChipType2 = # of samples in the 1 chip half of type 2 (Match Preamble)
1ChipType0 = # of samples in the 1 chip half of type 0 (Lack energy)
0ChipType2 = # of samples in the 0 chip half of type 2 (Match Preamble)
0ChipType0 = # of samples in the 0 chip half of type 0 (Lack Energy)

These counts are used to quantify how well each chip resembles a transmitted pulse or lack of pulse. The count range depends on the sampling rate used. Testing has shown that the technique works better if less weight is given to the samples near the transitional areas of each chip (the transitional samples are the samples located at each end of the chip). To facilitate this, samples other than those in the transitional area count double. Therefore, with weighting factored in, at an 8 MHz sample rate the counts will range from 0 to 6 (2 samples in the transitional areas + 2 samples in-between x 2). With higher sampling rates the counts will increase in range accordingly (10 MHz sample rate will range from 0 to 8, etc.)

These counts are used in the following equations to determine the 1Score and the 0Score:

1Score = 1ChipType2 – 0ChipType2 + 0ChipType0 – 1ChipType0
0Score = 0ChipType2 – 1ChipType2 + 1ChipType0 – 0ChipType0

The scores will quantify how well the bit resembles a transmitted ‘1’ or ‘0’. Whichever score is higher determines the bit value. For example, an ideal 1 bit will have a 1Score of 12 and a 0Score of –12. (An ideal 1 bit is where all samples in the first chip are of type 2 and all the samples in the second chip are of type 0.) Due to samples in the pulse transitions and in the presence of interference, the score difference may be less extreme but except in cases of severe interference the bit value can be determined with high confidence.

Confidence value is set to high if the difference in the two scores exceeds a threshold value. The technique was developed with a 10 MHz sample rate. Extensive testing using varying levels of interference and amplitudes has determined that with a score difference of 3 or more, high confidence should be assigned, otherwise low confidence is assigned. If other sampling rates are used, the confidence threshold may need to be adjusted.